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# Historical trends in size and endemic species for serpentine barrens in Pennsylvania

"Symphyotrichum depauperatum at Nottingham by Choess

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GEO 600 ~ Final Project 2015

**Abstract**

The serpentine barrens are unique ecological niches in North America, many of which are located on the Maryland/Pennsylvania border along the Mason Dixon Line. These areas contain grasslands and savanna ecosystems with rare and endangered flora and fauna that have interested botanists, biogeographers, geologists, plant physiologists, and nature enthusiasts since John Bartram, Benjamin Franklin, and John Fothergill, M.D. (Alexander 2009; Dann 1988; Pennell 1930).

Since the European settlement of the North American continent in the 1750's, the barrens have remained relatively stable. However in the past 50 years natural fires have been suppressed, grazing and logging have ceased, and the advent of developments such as shopping centers, golf courses and suburban housing further threaten these sensitive sites (Latham 1993, Tyndall 1992a). Trees and invasive woody plants have subsequently encroached upon the grasslands and savannas; the reduction in open serpentine areas is evident through comparisons of historical aerial photographs to current ones (Latham 2008, Tyndall 1992a).

The current methodology was to compare the sizes of local Pennsylvania serpentine barrens grasslands from historic and current photographs and maps and compare historic and current lists of endemic and known serpentine flora data. I hypothesized that the number of flora endemic and known to serpentine areas decreases with the reduction in size of open grasslands and savannas. My review of the current and historic plant lists and literature indicate that northeastern temperate grasslands and savannas are decreasing in size or disappearing, and the result is a reduction in serpentine barrens biodiversity.

**Introduction**

The Serpentine barrens grasslands and savannas are ancient ecosystems that are dependent on disturbances such as fire and grazing for their preservation (Latham 2008).

The flora and fauna that have adapted to the xeric and challenging conditions of this environment are threatened with extinction as these grasslands and savannas shrink with the encroachment of woody plant species (Tyndall 1992).

During the fall of 2014 I visited the 630 acre Nottingham Park twice where I observed the contrast between the vegetation of the barrens areas and the surrounding temperate deciduous forests and agricultural fields. The Nottingham barrens are overgrown with pitch pine, green briar and assorted invasive woody plants to the point that any venture from the maintained trails was accompanied by an assault of ticks and thorns. White tailed deer leapt away upon our advance. An assemblage of plants along the trails was blooming with pink, white, and yellow flowers. The trail traversed open rocky areas where the temperature felt hotter than the surrounding shaded areas. Abandoned mining pits exposed layers of rocks overgrown with vines and other vegetation. The trail meandered into the forests, crossing several streams where moist soil flora such as ferns and skunk cabbage grew, and insects such as dragonflies were observed. The trail ended where it began in a well maintained open pine forest near the rangers' offices and public parking lot.

On February 5, 2015 I attended a Serpentine Barrens Stakeholders meeting held at the Nottingham Park offices. The Nature Conservancy (TNC), which partially owns and manages several of the state-line barrens (Chrome, Fern Hill, Goat Hill, New Texas, Nottingham, and Willisbrook) was represented by Ms. Molly Anderson, the volunteer program manager, and other TNC personnel. Also present were several park rangers, researchers, including a biologist from West Chester University (WCU), and a few of the Friends of the Serpentine Barrens including the Friends field management volunteer leader who has been leading volunteers into the barrens to clear paths and assist in tree removal for many years. After the meeting one of the Nottingham park rangers escorted several of us into the barrens and we observed their management practice of cutting down and removing woody plants from overgrown areas of the barrens. As we passed a small triangle of exposed rock the ranger noted that all of the rarest barrens flora could be found in this one small open area which was approximately 15' x 15'. After this walk,

Stephen Winner, a barrens volunteer, agreed to take a few of us into the Goat Hill serpentine barrens in the spring.

I began my research on the serpentine barrens with a review of the literature which revealed that the northeast temperate grasslands and savannas were the most threatened of any global ecosystem (Latham 2005). Worldwide 46% of temperate grassland, savannas, and shrubland have been destroyed; 5% have been protected (Latham 2008). Of the ten historically mentioned serpentine barrens in Delaware County, only Pink Hill remains (Latham 2008). In Pennsylvania eight serpentine barrens remain in Chester County and two in Lancaster County; six other historically mentioned barrens in Chester County have been lost due to development or neglect (Latham 2008). MacArthur & Wilson's theory of Island biogeography suggests that species number is determined by the size and isolation of the island (Noss and Cooperrider, 1994). I hypothesized that the number of serpentine species is determined by the size of the grasslands or savanna areas; the smaller the area, the smaller the number of species present.

Below is a current photograph of a former site of one of the Middletown barrens that was researched by F. W. Pennell in the early years of the twentieth century known now as the Granite Run Mall (Latham 2008). The name Riddle was also associated with a former serpentine barrens site.

Harshberger (1903) researched the vegetation of ten serpentine barrens areas in Montgomery, Delaware, Chester and Lancaster counties in Pennsylvania. Pennell also began researching the Pennsylvania serpentine barrens as a University student in the summers of 1908 and 1909 and continued to research and publish scholarly papers regarding the flora of the barrens until 1930. The analysis focused on a comparison of these historic lists of serpentine area vegetation to current inventories of plants found on the barrens. This task was complicated by the disorganization of the historic plant lists, the lack of information regarding the importance of each taxa in the landscape, and changes in scientific names due to changes in species or subspecies status.

**Figure 1:** Granite Run Mall


The loss of northeastern temperate grasslands is clearly illustrated by comparing 1937 and 1938 aerial photographs taken from the Penn Pilot website to current maps of the barrens areas. The objective was to determine whether the shrinking grasslands corresponded to shrinking biodiversity, as suggested by the MacArthur & Wilson theory of Island biogeography that species number is determined by the size and isolation of the island (Noss and Cooperrider 1994), or in this case the size and isolation of the grassland.

In April 2015 I and four others, including a Nature Conservancy representative, a biologist, and volunteers Stephen and father Rich Winner, spent four hours walking through the Goat Hill serpentine area. Rich Winner has been walking through Goat Hill for 35 years. He shared his knowledge of the area and the changes that he has observed through time. He mentioned that an overturned all-terrain vehicle (ATV) started a fire twelve years ago. This fire burned out the greenbriars and scorched and burned some

trees. Several years post fire he noted that the green briars had returned perhaps even more aggressively as the reduction in canopy increased the amount of light reaching the ground. He mentioned that in cold winters the white tailed deer will gather in the open barrens grasslands and graze heavily. He added that horseback riding, dirt bikes, ATVs and off road trucks have caused damage to vegetation and trails that are now heavily eroded. He also noted that the Philadelphia Electric Company (PECO) cleared out a wide swath of trees and woody plants when they installed massive power towers. The exposed rocks were compacted by their heavy equipment and the site of an underground hot springs from which steam once rose was eliminated. During this walk about the biologist present found two varieties of native orchids one of which was called "Rattlesnake Plantain" (*Goodyera pubescens).*

Also in April 2015 I visited the ChesLen preserve, site of the "Unionville barrens." A longtime resident of the area escorted me through private property where one small grassland (perhaps 30' x 30') delighted us with the pink blossoms of *Phlox sublata* and white blooming *Saxifraga umbrosa*. Deciduous trees and greenbriar surrounded the small grassy glade. NLT has been logging adjacent larger grassland areas (NLT 2015 conversation). The deep treads of bulldozing equipment and enormous piles of cut red cedars were evident as we headed west. Old mining pits near overgrown mounds of pilings were ubiquitous.

Managing these remnant grasslands is a herculean task. An amazing ecosystem of flora and fauna that is not fully understood will be lost if preservation does not quickly stem the disappearance of serpentine barrens sites that are part of our natural heritage and deserve to be recognized as such.

**History**

The term serpentine is specific to rocks containing a group of minerals that includes antigorite and chrysotile, and is loosely applied to many types of weathered ultramafic rocks which contain high levels of magnesium (Mg) and iron (Fe) (Brooks 1987). The process of serpentinization occurs mainly by adding water to igneous minerals (Brooks 1997). Serpentine soil composition varies widely but in general

contains high concentrations of magnesium, iron, manganese, chromium, nickel and cobalt with low concentrations of calcium, nitrogen, phosphorus, potassium, and molybdenum (Dann 1988). The Ca/Mg quotient (low calcium, high magnesium) differs from normal soils and is often accompanied by a low pH (Brooks 1987). The two most common members of the Serpentine Group are:

Antigorite - $(Mg,Fe)_3Si_2O_5(OH)_4$, and;
Chrysotile - $Mg_3Si_2O_5(OH)_4$ ( minerals.net 2015).

Brook's (1987) formula for serpentinization is: $3MgSiO_4 + 4H2O + SiO_2 = 2Mg_3Si_2O_5(OH)_4$.

The North American continent was built upon a Precambrian craton (stable area of the plate). On the east, the Appalachians resulted from the collisions and separations that occurred over time between the American and Eurasian and African plates. On the west, the Cordilleran Range resulted from the collisions between the American and Pacific Plates (Brooks 1987). On the East Coast along the plate lines the ocean floor was thrust up to form a belt of ultramafic rocks extending from Newfoundland to Alabama. These ophiolites (mafic and ultramafic igneous rocks) date from the Paleozoic era (Dann 1988) more than a quarter of a billion years ago (Alexander 2009). Serpentine minerals formed when seawater leaking into the cracks of the ocean's foundations reacted with the minerals olivine and pyroxene (Latham 1993). Serpentine outcrops of the Piedmont Upland area passing through Maryland, Pennsylvania and Delaware were gradually exposed due to the processes of erosion through rain and landslides (Brooks 1987, Latham 2008).

Ultramafic rocks in the Baltimore mafic complex are composed of serpentinized dunite and chromitite with peridotite layers (Alexander 2009). In the Central Piedmont shear zone ultramafic rocks metamorphosed into soapstone (composed of talc, chlorite and tremolite) and serpentinite (Alexander 2009). Sites of soapstone quarries on the Susquehanna River dating back possibly five thousand years or more were excavated by William Henry Holmes in 1890 (Dann 1988). Artifacts of soapstone bowls and tools have been found from Georgia to Long Island (Dann 1988). In the Hall of North American

Indians at the National Museum are displayed some of these soapstone bowls and tools from the Washington D. C. quarry. Despite Holmes' preservation efforts nothing remains of the small creek and ancient quarrying sites located between what is currently Connecticut Avenue and Massachusetts Avenue, in Washington D.C. (Dann 1988). A working industrial steatite quarry in Millbury, Massachusetts was carbon dated to be approximately 2,730 years old. With the development of ceramics in approximately 700 BC, the use of the steatite quarries waned (Dann 1988).

Serpentine rock is structurally and chemically complex (Dann 1988). Serpentine was valued as a building stone in the nineteenth and early twentieth centuries There are many "green" buildings built from serpentine stone in and around the Philadelphia and Baltimore area including the "Green Library" of West Chester University and the University of Pennsylvania's Logan Hall and College Hall (Latham 1993). Serpentine rock is susceptible to the carbonic acid formed when smoke and car exhaust combine with water (rain and fog). This acid combines with the serpentine rock to form soluble magnesium carbonate which accounts for the disintegration of the "green buildings" (Latham 1993). Chromium was another mineral mined in the serpentine formations. Maryland and Pennsylvania were the world centers of chromium mining in the late 1800's. Other mined minerals were talc, asbestos and corundum (Latham 1993).

The map below (Figure 2) reprinted from Brooks 1987, illustrates the locations of the serpentine outcrops in the Piedmont uplands of eastern United States. The "State line" serpentine areas occur along the MD/PA border and include local serpentine barrens in Lancaster and Chester Counties, Pennsylvania.

**Plant Adaptations**

In eastern North American, 90% of serpentine outcrops are in Maryland and Pennsylvania (Latham 1993). Although ultramafic vegetation represents only 1% of the world's plant population, botanists have studied the flora of the serpentine barrens for over 100 years (Smith and Barnes 2008). The appearance of serpentine barrens was noted by John Bartram in a letter dated December, 1745 as "a particular kind of stone that runs near east and west for sixty or seventy miles or more . . . .Hardly anything else (besides a

described fern and flower - possibly *Cerastium velutinum* Raf.) grows here" (Latham 1993).

**Figure 2:** Serpentine sites in Maryland and Pennsylvania from Dann 1988

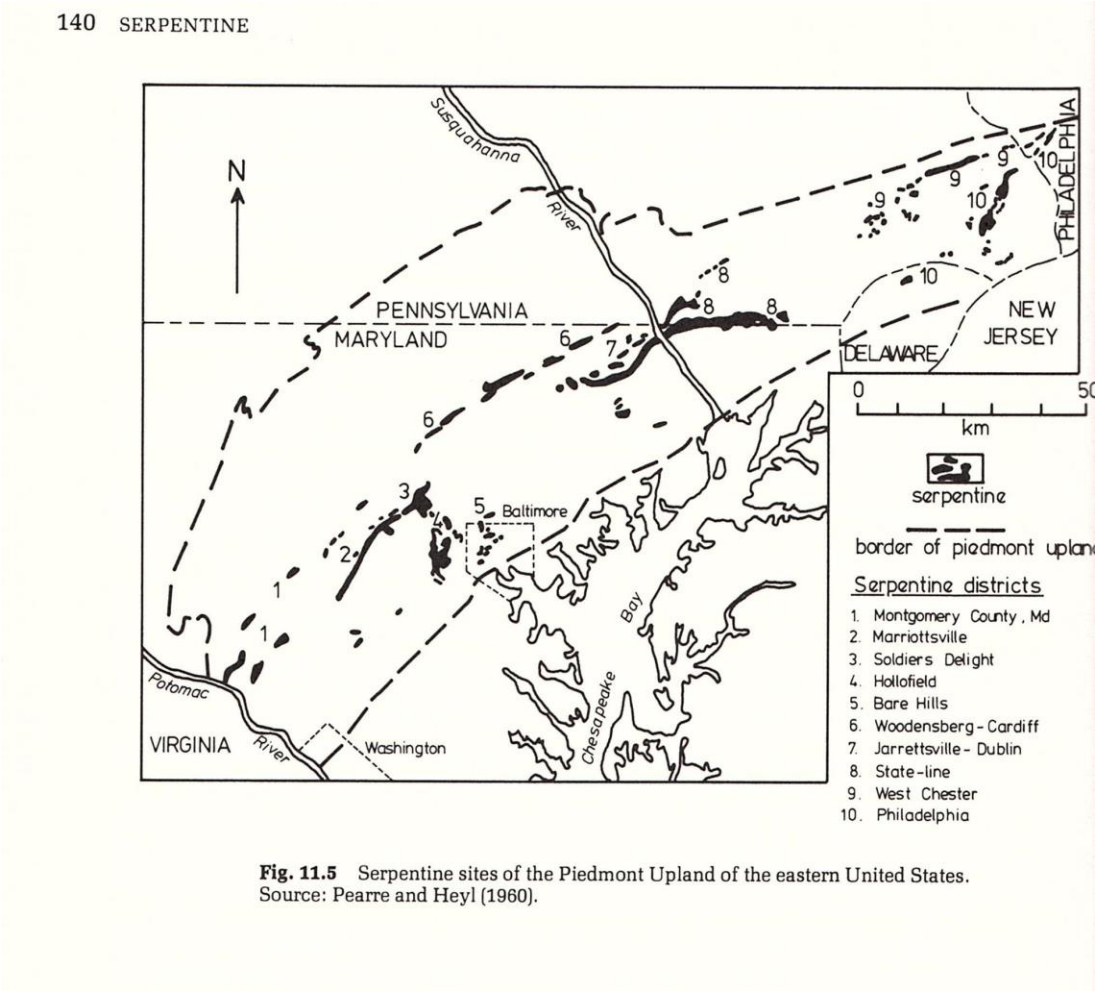



**Fig. 11.5** Serpentine sites of the Piedmont Upland of the eastern United States. Source: Pearre and Heyl (1960).

Brooks (1987) describes Kruckeberg's 1967 experiments noting that plants have a genetic/adaptive response to their environments. Plants growing on serpentine soils adapt to a less than ideal environment that may have thin soils and xeric conditions combined with a unique assortment of minerals such as high levels of nickel, chromium, and magnesium and low levels of calcium and molybdenum (Latham 2008).

Serpentine plants have adaptions such as narrow leaves and pubescence that give them an advantage over other plants in a dry and infertile environment (Hart 1980). Globally, plants growing on ultramafic outcrops have similar morphology including basal

rosettes, linear leaves and succulence (Latham 1993). In a series of experiments, Hart (1980) found that serpentine plants can thrive in fertile soils but are unable to compete on the same site with weedy plants that mature, reproduce, and grow rapidly. In another experiment, when researchers stopped watering the serpentine and non-serpentine plants, the serpentine plants, specifically the serpentine plant *Aster depauperatus,* showed the highest level of drought tolerance (Miller 1977). Serpentine soils can run from very shallow to quite deep (Alexander 2009). Serpentine vegetation may be adapted to fire disturbances, such as the grass species *Angropogon scoparius* (Miller 1981), and trees and shrubs with small or leather leaves such as *Corylus americana*, *Quercus marylandica* and *Quercus stellata* (Sladky 1981). Serpentine barrens, such as the Goat Hill barrens, also contain special microclimate patches where remnant boreal plants somehow survived in moist cool shaded areas along a creek or river bank such as the boreal form of maiden hair fern (*Adiantum aleuticum*), wild columbine and walking fern that are found along one section of the Octoraro Creek in Pennsylvania (Smith and Barnes 2008).

**Taxonomy**

Many of the serpentine plants collected by the early botanists can be found in Philadelphia in the Academy of Natural Sciences building (Dann 1988). William Baldwin, the Bartrams, Pursh, Darlington, Rafinesque, Harshberger, Long, Pennell, and Wherry were among the botanists who collected the 2 million specimens currently held in the Academy (Dann 1988). These botanists were challenged with the task of ascertaining whether similar plants were a variety or a distinct and separate species. For example, in 1814 Frederick Pursh named a narrow-leaved chickweed *Cerastium tenuifolium* Pursh.; he believed a hairier chickweed to be *Cerastium arvense*. John Torrey gave the name *Cerastium oblongifolium* Torrey to a chickweed from non-serpentine soil in Western Massachusetts. In 1813 Henry Muhlenberg named the chickweed he found on serpentine barrens in Chester County *Cerastium villosum* Muhlenberg, a new species (Dann 1988). In 1837 William Darlington wrote that Dr. Torrey felt the hairy chickweed was not *Cerastium oblongifolium*; he therefore adopted the *Cerastium villosum* nomenclature for the plant (Dann 1988). Finally in 1908 and 1909 the University of Pennsylvania student, F. W. Pennell spent his summers studying the serpentine barrens in Delaware and Chester

counties; he found the extra hairy chickweed on the banks of the Octoraro and resolved the chickweed puzzle. He renamed Pursh's chickweed *Cerastium arvense,* renamed Muhlenberg and Darlington's chickweed *C. arvense* var. *villosum,* and the hairy broad leaved Octoraro plant became C. *arvense* var. *villosissiumum* ("extra hairy") (Dann 1988). This chickweed, *Cerastium arvense* var. *villosissimum* is a true endemic to eastern North American serpentine barrens as it is found nowhere else (Gustafson and Latham 2005).

Biologists of the past did not have DNA analysis tools in their toolkits. D. Gustafson and R. E. Latham (2005) extracted DNA samples from the rare serpentine aster *Symphyotrichum depauperatum* to determine whether this aster was a separate species or a variant of another aster, *S. parviceps.* The protection of federally listed endangered and threatened species can change or lower if the plant in question is determined not to be a separate species. This aster is only known to grow in Maryland and Pennsylvania serpentine barrens with the exception of a disjunct population in North Carolina (Gustafson and Latham 2005). Their results based on an analysis of tissue samples using amplified fragment length polymorphism (AFLP) indicate that this aster is a distinct species growing only on 20 of the remaining 26 eastern North American serpentine barrens of 2.0 ha or greater with three small populations still extant in North Carolina (Gustafson and Latham 2005).

**Disturbances, Threats and Invasions**

Temperate grasslands and savannas are the most endangered of any global ecosystem (Latham 2005). Nearly half of these areas have been destroyed; only 4.6% have been protected (Latham 2005). North American Eastern temperate grasslands and savannas are the most severely threatened (Latham 2005). There is no law in Pennsylvania that can be invoked to protect these areas of rare flora and fauna and cultural history (Latham 2005).

Disturbances like fires and grazing kept the grasslands open for millions of years (Latham 2005). In the past, giant herbivores such as the wooly mammoth, and the American mastodon, along with other mid-sized herbivores like elk, moose, and deer,

effectively prevented the grasslands from succeeding to forests (Latham 2008). The extinction of these grazing animal coincided with a wave of human immigration that began around 13,000 years ago (Latham 2008).

The serpentine barrens outside of Unionville, Pennsylvania had 58 acres of grasslands and savanna in 1938. In 2005 the open area was reduced to 8.9 acres, a loss of area of about 60% (Latham 2005). The rate of shrinkage of open grassland accelerates over time as the edges fill in with trees and invasive species (Latham 2005). The plants and animals that depend on this ecosystem become increasingly vulnerable to extinction as the area shrinks (Latham 2005).

Tyndall and Farr inventoried 44 vascular plant taxa on the serpentine barrens in Cecil County called Pilot, and 69 vascular plant taxa on the four times larger Cherry Hill barrens (Tyndall and Farr 1990). In the case of rare flora and fauna, the larger the habitat, the greater the chance of survival (Tyndall and Farr 1990; Noss and Cooperrider 1994). This research also suggests that drought is effective in reducing succession of grasslands to invasive pines (Tyndall and Farr 1990).

What other disturbances besides grazing animals have preserved these open grasslands in the past? The last period of global warming occurred between 8,000 and 4,500 years ago with resultant droughts and frequent fires (Latham 2005). When the climate got wetter and cooler, about 4,500 years ago, the lightning-induced fire frequency rate reduced to zero (Latham 2005). However, Native Americans likely ignited fires either purposely or accidentally on a regular basis (Latham 2005). Circumstantial evidence indicates that grasslands in Eastern North America are an Indian artifact (Latham 2008).

In Knox's study of four stands of trees in the 800 acres of Soldier's Delight serpentine barrens in Maryland, the similarity in age and species of each of these stands strongly indicated a disturbance regime. Fire scars on the oaks and sassafras trees indicated the probability of fires recurring every 8 to 40 years since 1850 (Knox 1984).

Arabas (2000) researched fire and land-use history for her study of the Nottingham, Pennsylvania barrens. She found that the savanna areas of the Nottingham

barrens have reduced by half between 1937 and 1993; hardwood forests have increased from 2% to 25% (Arabas 2000). Her research did not find direct evidence of regular fire disturbances by Native Americans in the Nottingham barrens. Smith and Barnes (2008) found no evidence of Native American fires at the Goat Hill barrens. However, the practice of using fires for cooking, clearing land for agriculture, and hunting may have gone on in this area for thousands of years. The Europeans adopted these Native American practices when they arrived in America (Arabas 2000). From 1888 to 1978, the average mean fire return interval from archived records of the Nottingham barrens was 10 years (Arabas 2000).

Since 1936 active fire suppression using advanced fire control methodology to protect homes and livestock has taken place (Arabas 2000). The succession pattern at Nottingham barrens (and all of the barrens) from grasslands and open savanna to mesic forest will continue unless regular disturbances like fires, grazing, or scraping are used as management practices (Arabas 2000).

Miller (1981) analyzed the vegetative cover at the Rock Springs barrens in southern Lancaster County. Three fires of unknown origin burned an area of about fifty acres in these barrens commencing with the first fire in April 1969, the second in August 1972 and the third in April 1978. Miller's results indicate that serpentine vegetation is fire adapted and that fire may be an important management tool for controlling plant succession and species composition on serpentine barrens. Both *Pinus virginiana* and *Juniperus virginiana* showed that they were unable to withstand fires. *Acer rubrum* has an ability to grow root shoots and improved its succession position post fire as did the dominant ground cover *Andropogon scoparius* (Miller, 1981). *Pinus rigida*, *Quercus marilandica* and *Quercus stellata* have the ability to send out shoots from epicormic buds following a fire event (Latham 1993).

Mining and quarrying took place in many of the State line serpentine barrens. Evidence of mining is seen in deep pits and vegetated mounds near these pits in all of the barrens visited. The Unionville barrens were mined from the 1820's to around 1900 for corundum (used as an industrial abrasive until the invention of synthetic silicon carbide),

diaspora (a rare mineral found in the 1820's by the amateur mineralogist William Jefferis), tourmaline (a blue green gemstone), feldspar (used for creating ceramics such as false teeth) and chromite (used as a pigment in paint) (Latham 2005). There is at present an active mining operation on serpentine barrens in southern Lancaster County producing crushed stone for paving and concrete (Latham 2005).

Farmers may have grazed domestic animals on the barrens as the soils were not suitable for agriculture (Tyndall and Farr, 1989). As the human population post WWII increased, developments such as suburban homes, shopping centers, golf courses and parking lots encroached and usurped serpentine barrens. Granite Run Mall, recently sold and slated for demolition and redevelopment (The Mercury News 2015), was built on the site of a serpentine barren. Pink Hill is the only undeveloped serpentine area left in Delaware County, Pennsylvania.

One hundred years ago the northern Piedmont serpentine areas were grasslands with trees growing only in ravines or riparian areas (Alexander 2009). When burning and grazing stopped, the grasslands were invaded by the conifers *Pinus virginiana* (Virginia Pine), *Juniperus virginiana* (Virginia Juniper), and *Pinus rigida* (Pitch Pine). Research on the Chrome barrens indicated that the pine trees affected the soils there by increasing the depth of the soil, lowering the surface soil pH, and increasing the Ca/Mg ratios (Alexander 2009; Barton and Wallenstein 1997). These changes make the soil more favorable for other invasive flora to grow on serpentine soil (Alexander 2009), and facilitate the succession from grasslands and savannas to forest (Barton and Wallenstein 1997). Harshberger (1903) wrote that the flora of the serpentine barrens of southeast Pennsylvania was "sharply demarcated" from the flora of the sounding countryside. He describes the flora of ten serpentine areas, probably all no longer in existence with the exception of Pink Hill which is protected within the Tyler Arboretum. He lists the flora of the serpentine forested areas as well as the open grasslands; interestingly *Juniperus virginiana* is found in all of these forests which he describes as a mixed deciduous formation of *Juniperus-Acer-Nyssa-Quercus*. Harshberger (1903) does not list any Pinus species in these ten barrens at the turn of the twentieth century.

Miller (1977) describes and compares the various stages of succession and the accompanying flora of both non-serpentine and serpentine soils. During the second stage of succession on serpentine soil (8-20 years post non-management), *Juniperus virginiana*, *Pinus virginiana,* and *Acer rubrum* become dominants on serpentine soils. No *Pinus* species are listed in the six stages of succession in the non-serpentine soils as they are shade intolerant. Latham (1993) notes that invasion of serpentine barrens by non-serpentine vegetation greatly threatens the grasslands and savannas. *Robinia pseudoacacia* trees (native to the Ozarks and Appalachian mountains introduced to the East by Europeans) are aggressively growing at Pink Hill where their ability to sprout and regenerate make them difficult to exterminate (Sladky 1981). *Pinus rigida* has created a nearly closed canopy in the Goat Hill barrens (Latham 1993). Invasive species that threaten serpentine vegetation include *Ailanthus altissima*, *Berberis thunbergii, Celastrus orbiculatus, Lonicera japonica, Lonicera maackii,* and *Smilax rotundifolia,* among others. The unimpeded succession of grasslands and savannas by both native and nonnative invasive plants reduces an area of rich biodiversity of rare and endangered species to one of an ordinary temperate forest with low biodiversity (Latham 2008).

During the summers of 1908 and 1909 and again in the summers of 1911 and 1912, Francis W. Pennell researched, collected, and listed the flora of the southeastern Pennsylvania serpentine barrens (Pennell 1910, 1912). He continued to research and update his serpentine barrens flora data in his 1929-1930 paper. J. W. Harshberger (1903, 1904) also gives us historical records of the flora of the southeastern Pennsylvania serpentine barrens, noting that each barrens area was unique in its assemblages of flora. These lists can be compared to current data of the flora of these areas. Unfortunately most of the barrens that these biologists studied are no longer in existence. Pennell (1912) lists five barrens in Delaware County, and six separate barrens in Middletown Township in Delaware County. In Chester County he lists six different barrens with five separate areas within this group of six along with one in Centerville, and two in Nottingham (Nottingham and Goat Hill). He lists the location of these barrens in his 1912 paper by latitude and longitude.

Of the Delaware County group only Pink Hill still exists within the Tyler Arboretum; Sugartown barrens (Willisbrook), Fern Hill in West Chester, and the Unionville barrens in the ChesLen preserve still exist in Chester County. Harshberger (1903) researched ten barrens areas in Pennsylvania. Historic research would be needed to locate these areas that include: Glenriddle in Delaware County, east of the Black Horse Hotel, west of the Black Horse Hotel, serpentine at the Williamson school, serpentine between Newtown Square and Darby Creek, serpentine opposite Castle Rock on east side of Crum Creek along Preston Run, serpentine near Westtown, PA, Pink Hill in Delaware County, and Brinton's Quarry near Westtown. There is a Black Horse Road east of the Granite Run Mall, west of Media, PA, and perhaps the Williamson school is the high school south of the Granite Run Mall and Riddle Hospital. Both were known as serpentine areas in the past. Crum Creek lies east of the Granite Run Mall running north south parallel to the Blue Route. Harshberger's flora research provides occasional descriptions of the terrain and the predominant flora in each barrens area. He describes the East Side Crum Creek serpentine area along Preston Run:

> A large part of this exposure is treeless, and upon the broken-down serpentine rock grow mats of *Phlox subulata, Trifolium agrarium, Pteris aquiline, Verbascum blattaria, Panicum latifolium, Potentilla canadensis* and *Cerastium oblongifolium.* The trees are the same as the botanist finds on the other serpentine barrens mentioned. Thickets of green briars are also characteristic of the treeless areas here . . . When the growth of these trees is dense the serpentine areas are rendered impenetrable in many places by the green briars, *Smilax rotundifolia, Smilax glauca,* the lianes, *Vitis aestivalis,* and the Virginia creeper, *Ampelopsis quinquefolia,* which festoon the trees and intertwine with each other to form a dark gloomy forest inhabited by the cotton-tail rabbit (Harshberger 1903: 342).

Currently there are ten serpentine barrens in Pennsylvania: eight are located in Chester County, and two in Lancaster County. Four serpentine barrens are found in Maryland (Latham 2008). The total Eastern North American grasslands support over 100 rare and endangered species (Latham 2008). Pennsylvania hosts 37 of these species (based on historic records including Pennell 1910, 1912) that are listed as "special concern" species (Latham 2008). Pink Hill in the Tyler Arboretum was formerly home to 11 of these rare species but since 2008 only four have been reported, which includes the

rare *Symphyotrichum depauperatum.* The other 33 species are probably extinct in Pennsylvania (Latham 2008).

Generalizations regarding relationships between number of species and habitat area were first studied with respect to islands. As area of habitat declines, so do the number of species (Noss and Cooperrider 1994). This effect can be carried over to isolated "islands" of habitat such as wetlands, forest fragments or alpine grasslands (Noss and Cooperrider 1994). MacArthur and Wilson's equilibrium theory of island biogeography states that the number of species on an island represents a balance between the number of immigrant species and the number of species that become extinct (Noss and Cooperrider 1994). Large islands close to other land sources of immigration will contain a higher number of species than smaller isolated islands (Noss and Cooperrider 1994). Of the former eighteen serpentine barrens north of the Mason-Dixon Line, seven remain, and these have greatly reduced in size As these areas shrink and become further isolated, the rare and endangered serpentine barrens species are at increased risk of extinction (Latham 2005). Latham (2005) notes that three rare plant populations on the remaining intact grasslands in the Unionville barrens, one sedge and two grasses, now grow only in small areas within their total grassland habitat.

Increasing the area of the grassland "islands" will reduce the possibility of rare species going extinct (Noss and Cooperrider 1994). Practices could include edge mowing to reduce succession by woody plants, and control of invasive species including basal bark applications of herbicide to invasive trees (Latham 2005). Native grass species might be restored in prepared areas that were once grasslands but succeeded to forest during the post disturbance regime (Latham 2005).

**Methodology**

The methodology for this research was to review the historic flora lists of four of Pennsylvania's serpentine barrens (Harshberger 1903 and Pennell 1910, 1912, 1930) and compare them to the most recent flora inventories of the remaining barrens. I then compared 1937/1938 aerial photographs from the Penn Pilot website to current aerial

photographs from Google Earth or Arc Map to determine the change in the amount of open grasslands in the barrens.

Three of the four barrens researched, Fern Hill, Unionville, and Willisbrook, are in Chester County. Pink Hill is in Delaware County, the last serpentine barrens known to exist in this Pennsylvania County. All but Fern Hill are surrounded by preserved acreage. Fern Hill serpentine barrens are located within a housing development managed by the North Hill Civic Association. TNC has listed the Fern Hill site as deserving of protection in its registry. The Unionville barrens are part of the 1,263 acres of the Cheslen Preserve and are managed by NLT. Pink Hill is a small area inside of the 650 acre Tyler Arboretum, and managed by the Arboretum. Willisbrook barrens are inside the 126 acre Willisbrook Preserve, the first ever property donated to and managed by TNC since 1961.

Pennell (1910) gives us a complete list of the vascular plants in each of the state line serpentine barrens and descriptions of preferred habitat. However Pennell does not give us a broad view of the overall landscape or percentages of the plants that he lists (Latham 2008). Pennell also notes that each area contains its own unique assemblages of flora (Pennell 1910). He suggests that both the isolation of each separate barrens area plus the size of the area affect the number and quality of the species present (Pennell 1910). He adds that the sparse timber includes *Quercus stellata* on all the upland barrens, *Quercus marylandica* on most of the barrens, and *Pinus rigida* as a predominant tree on the State-line barrens. He mentions also *Sassafrass sassafras*, *Acer rubrum* and *Prunus serotina*, but does not mention *Juniperus virginiana* or *Pinus virginiana* which are prevalent today. The list below contains Pennell's inventory of flora from the "West Chester" barrens (which is probably the serpentine barrens of Fern Hill in 1910).

Pteridium aquilinum
Asplenium platyneuron
Juniperus Virginiana
Andropogon scoparius
Sorghastrum nutans
Paspalum pubescens
Panicum philadelphicum
Panicum depauperatum
Panicum annulum*
Panicum Huachucae silvicola

Panicum scribnerianum
Panicum sphaerocarpon
Panicum villosissimum
Homalocenchrus oryzoides
Homalocenchrus oryzoides
Aristida dichotoma
Aristida gracilis
Aristida purpurascens
Sporobolus Vaginae florus
Deschampsia caespitosa*
Atheropogon curtipendulus*
Cyperus aristatus
Cyperus strigosus
Cyperus filiculmis macilentus
Eleocharis tenuis
Fimbristylis laxa*
Scirpus atrovirens
Scleria pauciflora
Carex triceps hirsuta
Juncus effuses
Juncus secundus
Juncoides campestr
Smilax glauca
Smilax rotundifolia
Sisyrinchium mucronatum
Corylus American
Quercus ilicifolia
Quercus stellata
Polygonum tenue
Talinum teretifolium Pursh*
Silene stellate
Cerastium oblongifolium* probably C. arvense villosum ~ my note)
Arenaria stricta*
Arabis lyrata
Apirea latifolia
Potentilla pumila
Rosa humilis
Meibomia paniculata
Meibomia dillenii
Meibomia obtuse
Lespedeza virginica
Lespedeza hirta
Linum medium
Polygala verticillata
Rhus copallina
Ceanothus americanus
Vitis aestivalis
Hypericum punctatum
Sarothra gentianoides
Helianthemum majus
Lechea minor
Viola pedata
Viola fimbriatula
Kneiffia fruticosa
Azalea nudiflora
Gaylussacia baccata
Polycodium stamineum
Vaccinium atrococcum
Vaccinium vacillans
Diospyros Virginian
Sabbatia angularis

Asclepias verticillata*
Phlox subulata*
Scutellaria parvula*
Koellia flexuosa
Houstonia coerulea
Galium pilosum
Lobelia spicata
Nabalus serpentarius
Ambrosia artemislaefolia
Vernonia noveboracensis

Eupatorium perfoliatum
Eupatorium aromaticum
Solidago bicolor
Solidago rugosa
Solidago juncea
Solidago nemoralis
Sericocarpus asteroids
Aster laevis
Aster parviceps pusillus*
Aster lateriflorus
Antennaria neodioica Greene
Antennaria plantaginifolia
Gnaphalium polycephalum
Heliopsis helianthoides
Helianthus giganteus
Senecio balsamitae
Cirsium discolor
Cirsium muticum
Danthonia spicata
Carex lurida
Carex lanuginose
Carex glaucodea
Carex vulpinoidea
Carex retroflexa
Carex stricta
Carex incomperta
Carex scoparia
Carex normalis
Carex bicknellii
Juncus effuses
Juncus dichotomus platyphyllus
Juncoides bulbosum
Rubus frondosus
Rubus villosus
Rosa humilis
Lespedeza virginica
Lespedeza hirta
Kneiffia fruticosa
Azalea nudiflora glandifera
Vaccinium atrococcum
Leptandra virginica
Aster depauperatus*

Occasional species

Cyperus diandrus
Eleocharis palustris glaucenscens
Hypoxis hirsute
Leptandra virginica

Introduced species:
Poa pratensis

* = nearly or entirely restricted to serpentine barrens in Delaware and Chester County. (Pennell 1910)

Pennell's lists of total vascular plants in each of the serpentine barrens he inventories do not give us the relative importance of these species. He does give asterisks to the plants that he suggests grow only on serpentine barrens. If we separate out the plants that Pennell notes grow only in the serpentine barrens areas we would have the following eleven plant species.

Arenaria stricta
Asclepias verticillata
Aster depauperatus
Aster parviceps pusillus
Atheropogon curtipendulus
Cerastium oblongifolium
Deschampsia caespitosa
Fimbristylis laxa
Phlox subulata
Scutellaria parvula
Talinum teretifolium Pursh

Some of the names in this list of endemics stand out as currently rare and endangered. Pennell's *Aster parviceps pusillus* is the endangered Aster now called *Symphyotrichum depauperatum* (or seemingly used interchangeably, *Aster depauperatum).* Many of the grasses listed by Pennell are on Pennsylvania's rare, endangered, and/or extinct lists on the Pennsylvania Natural Heritage Program (PNHP) website. Wherry (1963) restructured Pennell's lists by organizing them in families, and alphabetizing the species. Some of the plant names on Pennell's list have been changed or reclassified such as the *Cerastium oblongifolium* which is either *C. arvense villosum* or *C. arvense* var. *villosissimum,* but in either case it is difficult to know to which plant he refers.

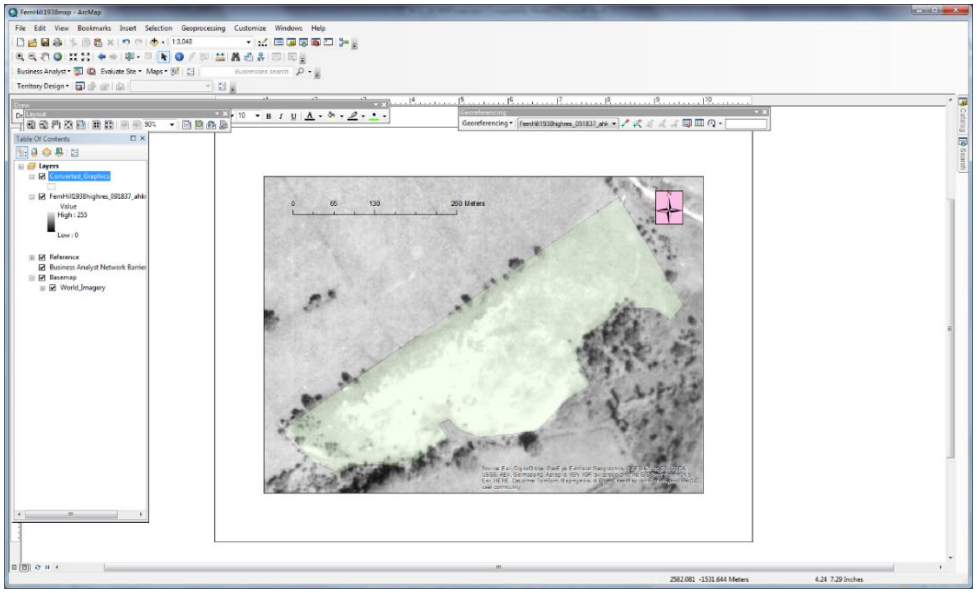
**Results**

I reviewed aerial photographs, beginning with the West Chester serpentine barrens, Fern Hill. The 1938 view (Figure 3) appears devoid of trees and shrubby plant growth within the serpentine site. No roads or housing developments are evident. The approximate serpentine grassland area, measured by using the polygon "draw" tool in Arc Map is 10.95 ha or 27 acres.

**Figure 3:** Fern Hill 1938

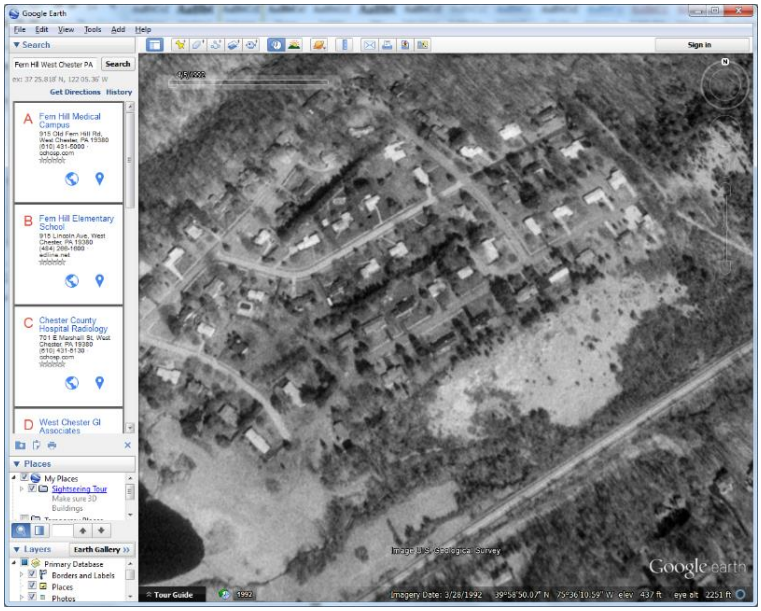
Figure 4 also illustrates a 1938 Pen pilot aerial photograph of Fern Hill, enlarged to better see the grasslands area.

**Figure 4:** Fern Hill open grasslands in 1938 enlarged (in green).



The 1992 Google Earth photograph of Fern Hill in Figure 5 illustrates the encroachment of woody plants along the edges of the barrens area, and a housing development with roads and landscape plantings.

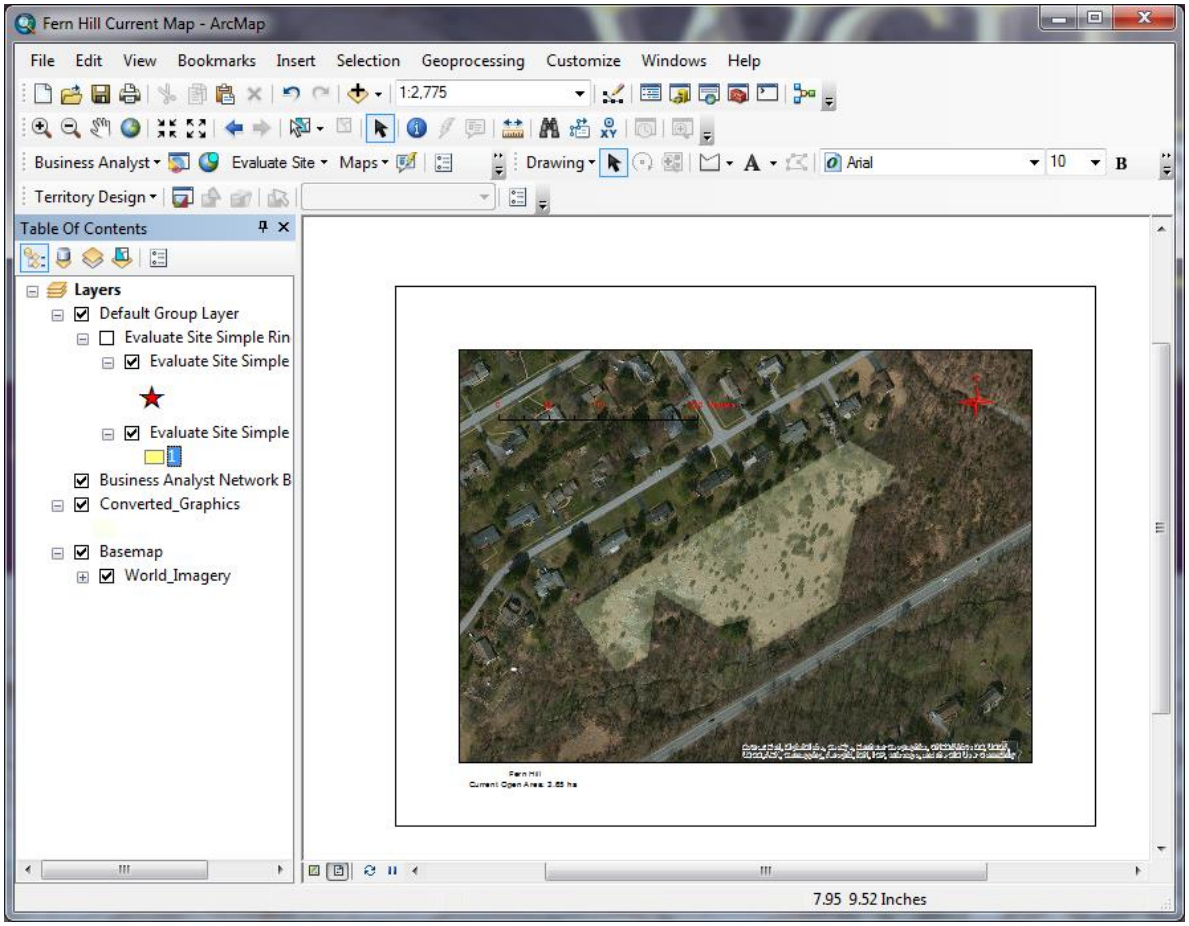
**Figure 5:** Fern Hill 1992




The 2011 Arc Map in Figure 6 further illustrates the encroachment of plants upon the grasslands. Fern Hill's open area has reduced from approximately 27 acres in 1938 to 9 acres currently.

The Fern Hill serpentine barrens are part of a development called North Hill which is managed by the North Hill Civic Association (NHCA). The Nature Conservancy (TNC) has listed Fern Hill in its registry as a place that deserves protection. TNC lists several endangered flora in its description of Fern Hill including the serpentine aster (*Aster depauperatus*), the round-leafed fame flower (*Talinum teretifolium*), the grass annual fimbry (*Fimbristylis annual*), and side-oat gramma (*Bouteloua curtipendula*). The surrounding trees are described as an oak sassafras forest.

**Figure 6:** Fern Hill 2011: 9 acres




The next barrens area that was included in both Harshberger and Pennell's plant lists is Pink Hill, now a protected area within the Tyler Arboretum. The 1937 size of the Pink Hill serpentine barrens open grasslands is represented in Figure 7 in pink. The Tyler Arboretum borders are included in green (Latham 2008).

**Figure 7:** Tyler Arboretum and Pink Hill serpentine grassland circa 1937 (Latham 2008)

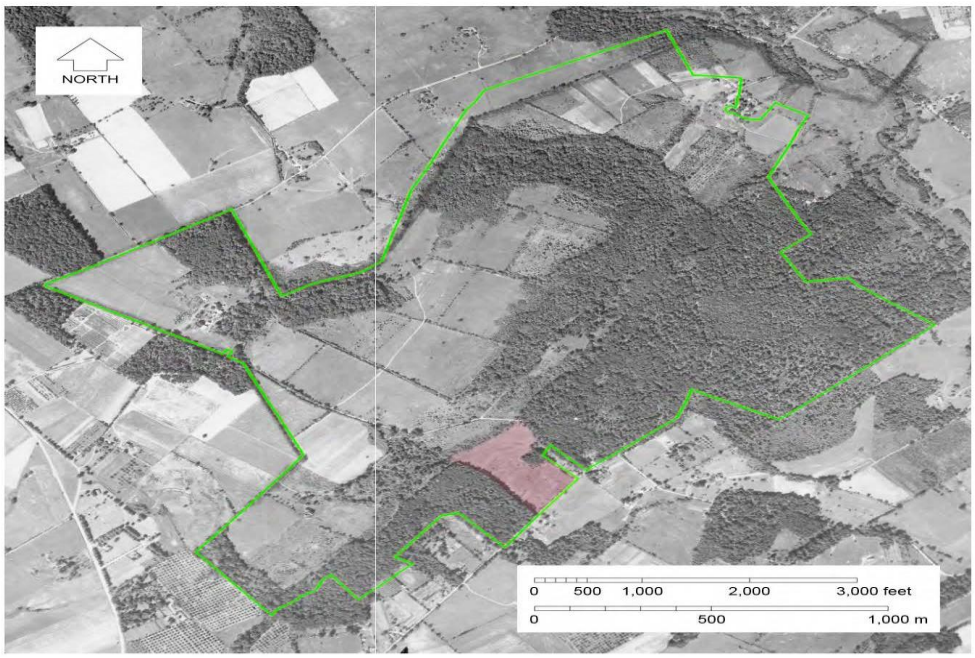



Figure 1. **Extent of Pink Hill grassland in 1937** (pink shading). The present-day borders of the Tyler Arboretum (green line) are superimposed on the earliest available aerial photograph of the area, taken on 18 September 1937. (See Figure 3 for a detailed map of the changes in grassland area from 1937 to 2005.)

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Figure 8 illustrates the shrinkage in the open grassland of Pink Hill based on aerial photography (Latham 2008). Serpentine flora species at Pink Hill have reduced from a turn of the century count of 37 to a total of 4 species currently (Latham 2005).

**Figure 8:** Changes in open grasslands at Pink Hill since 1937 (Latham 2008).


Figure 3. **Changes since 1937 in the area of serpentine grassland at Pink Hill** based on interpretation of aerial photography[1], overlain on 2005 aerial imagery[2]. Painter Road is at top; Barren Road is at lower right; green line is the Tyler Arboretum boundary.

[1] 1959–2005: Tim Dougherty, Joy Fritschle, Pedro Garaitonandia, Scott Greenly and Joan Welch; 1937: Roger Latham
[2] Delaware Valley Regional Planning Commission 2007

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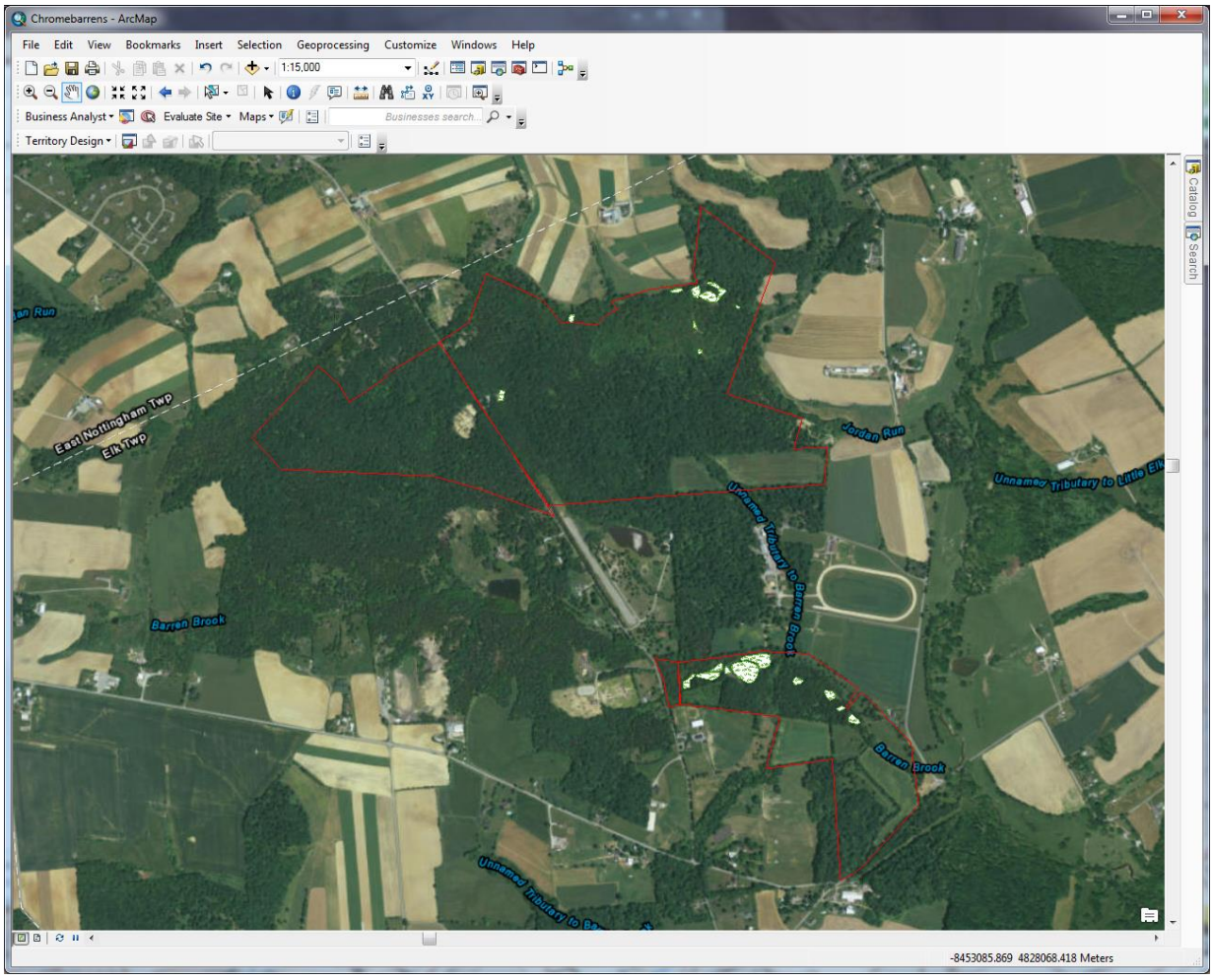
The Chrome Barrens also illustrates the increase in canopy cover and woody plant growth in a larger serpentine barrens since the suppression of disturbance regimes such as fires and grazing in the 1930's and 40's. Figure 9 is a current map using data from the WCU course GEO 324/534 2014 of the Chrome Barrens with open spaces in white and

drawn as polygons. I measured each open grassland area: the largest area was 1.83 acres, the smallest, 0.042 acres. Many of these small grassland openings are isolated by forest canopy and will soon close if management practices are not employed.

**Figure 9:** Chrome Barrens current with borders in red and grasslands in white (WCU GEO 2014 data)




The next map of the Chrome barrens is of a 1938 aerial photograph georeferenced and overlaid onto a current map with grassland openings in white and green. Chrome barrens borders are in red.

**Figure 10:** Chrome barrens in 1938 Chrome barrens with current grassland openings in white and green included.

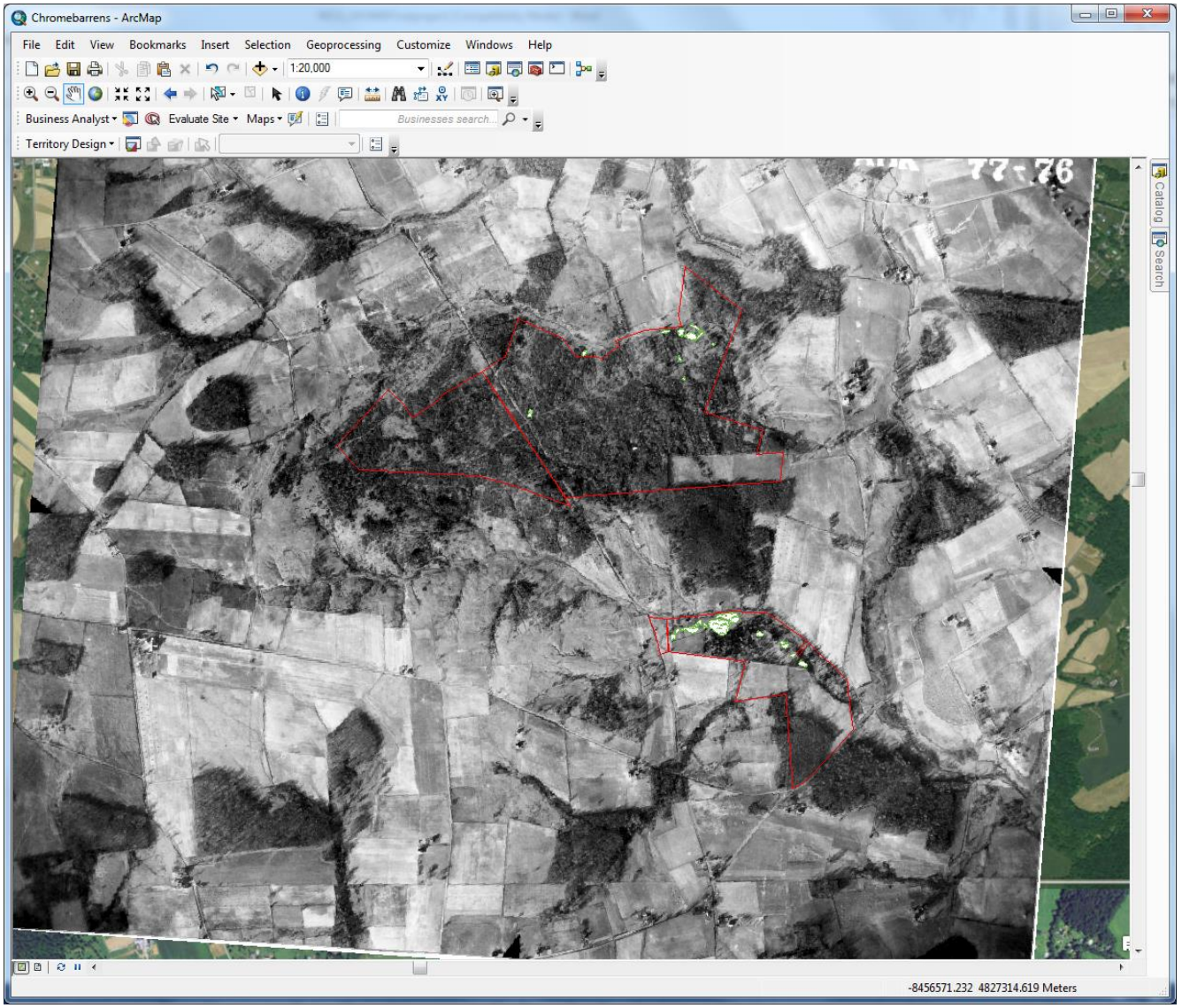
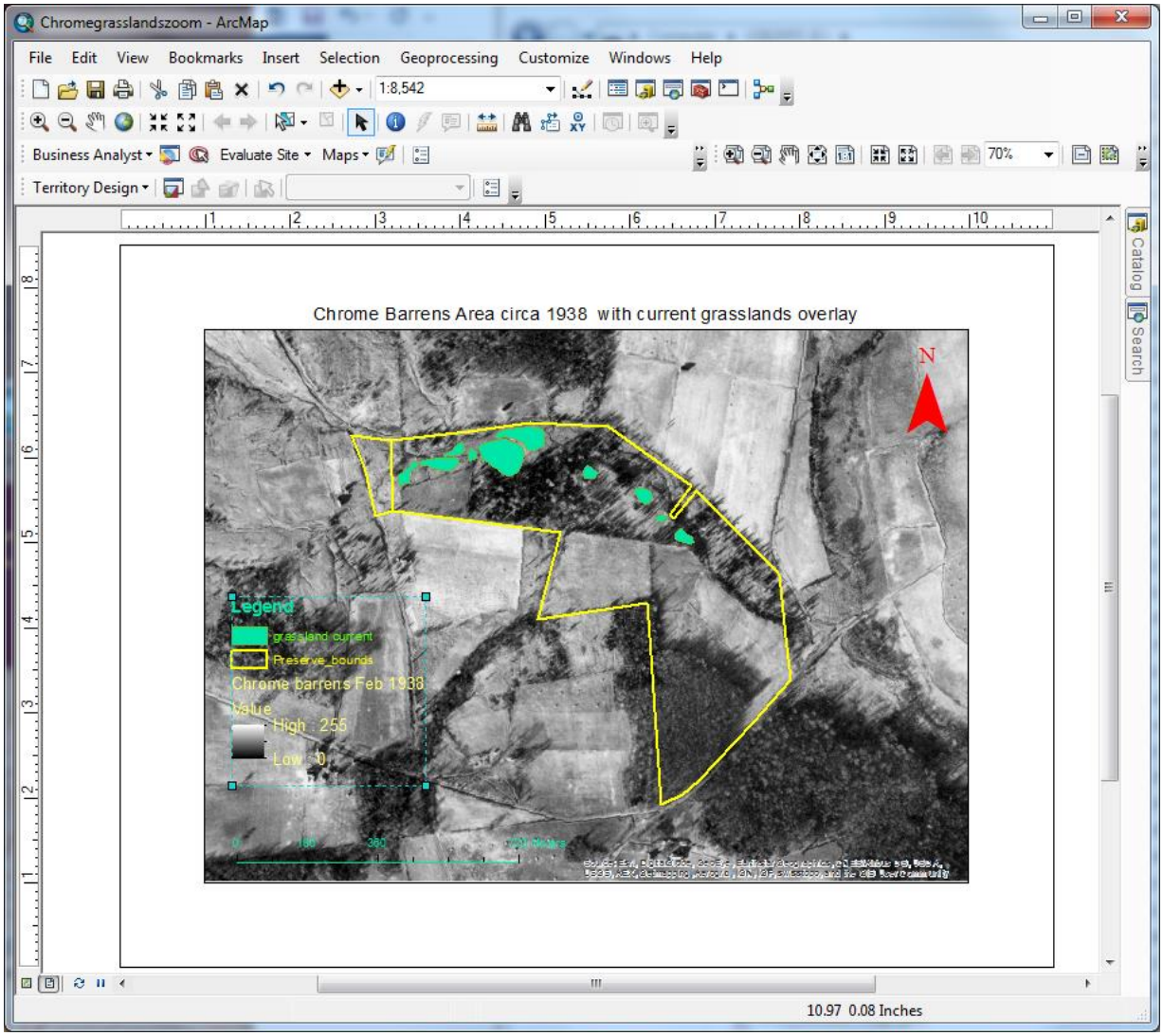



Figure 11 is an enlargement of the southern section of the Chrome barrens in 1938 with current grasslands. It is clear in the map that the current open grasslands areas in the Chrome barrens represent only a small percentage of the 1938 open grasslands areas.

**Figure 11:** Southern section of Chrome Barrens 1938 with current grasslands in green.




Roger Latham (Latham 2005) contributes a thorough inventory of the flora of the Unionville barrens. His maps of this serpentine area again illustrate the shrinking of open grasslands. The rate of loss of grassland accelerates with edge to area increase (Latham 2005). As the invasive plants and trees growing in the partial shade and protection of the woods increase, the grasslands shrink at an increasing rate (Latham 2005). The chart in Figure 12 illustrates the grassland losses in the Unionville barrens (Latham 2005).

**Figure12**: Rate of grassland loss in Unionville serpentine barrens (Latham 2005).

| Year | Area in grassland | Acres lost | Percent of loss | Amount per year |
|---|---|---|---|---|
| | | | | |
| 1937 | 58.1 acres* | | | |
| 1992 | 18.8 acres | 39.3 acres | 67.6% | 0.72 acre/year |
| 2002 | 8.9 acres | 9.9 acres | 52.5% | 0.99 acre/year |

* Included 6.8 acres south of Cannery Road.

Figures 13, 14, and 15 further illustrate the loss of grasslands in the Unionville barrens in the Cheslen Preserve.

**Figure 13:** Unionville barrens open grasslands in the Cheslen Preserve 1937. The grasslands (in yellow) are approximately 58 acres (Latham 2005).

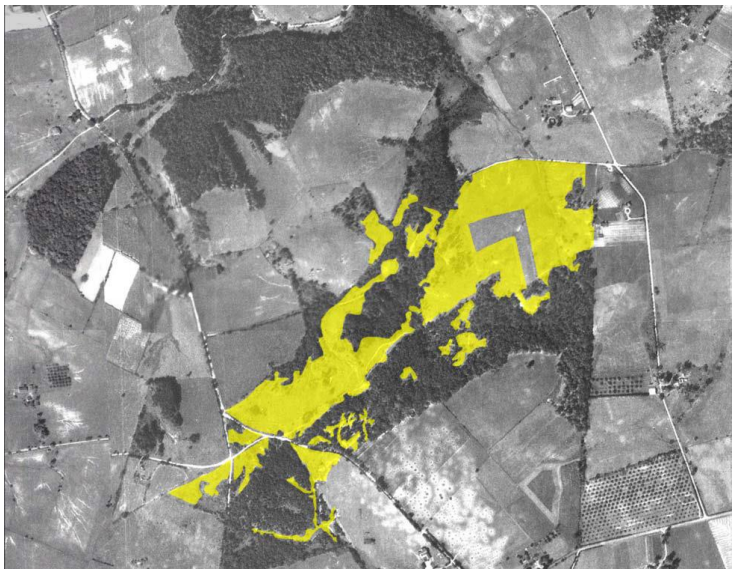


**Figure 14:** Unionville barrens open grasslands in 1992. The serpentine grassland (light green) covered approximately 19 acres (Latham 2005)

**Figure 15:** Unionville barrens 2002 serpentine grassland area in green (Latham 2005).

In 2002 the grassland in the Unionville barrens covered approximately 9 acres. The average loss rate over the preceding 10 years was nearly one acre per year (Latham 2005).

Latham and Ebert (Latham 2005) surveyed all the vascular plants found in the Unionville serpentine barrens; not included were plants found in the woods and fields surrounding the barrens. Amazingly, their total list of vascular plants numbered 173. When F. W. Pennell inventoried the Unionville barrens in 1908 he found a total of 110 vascular species on the Unionville barrens. Pennell (1910, 1912) does not describe the relative proportions of the plants he listed. Latham notes that the following plants were once found at Unionville but have not been found in over 40 years including: Downy lobelia (*Lobelia puberula* Michx.), arrow-feather three-awn (*Aristida purpurascens* Poir.), colic-root (*Aletris farinosa* L.) and lion's-foot (*Prenanthes serpentaria* Pursh). Of these four, only *Aristida purpurascens* is listed in Pennell's 1910-12 inventory.

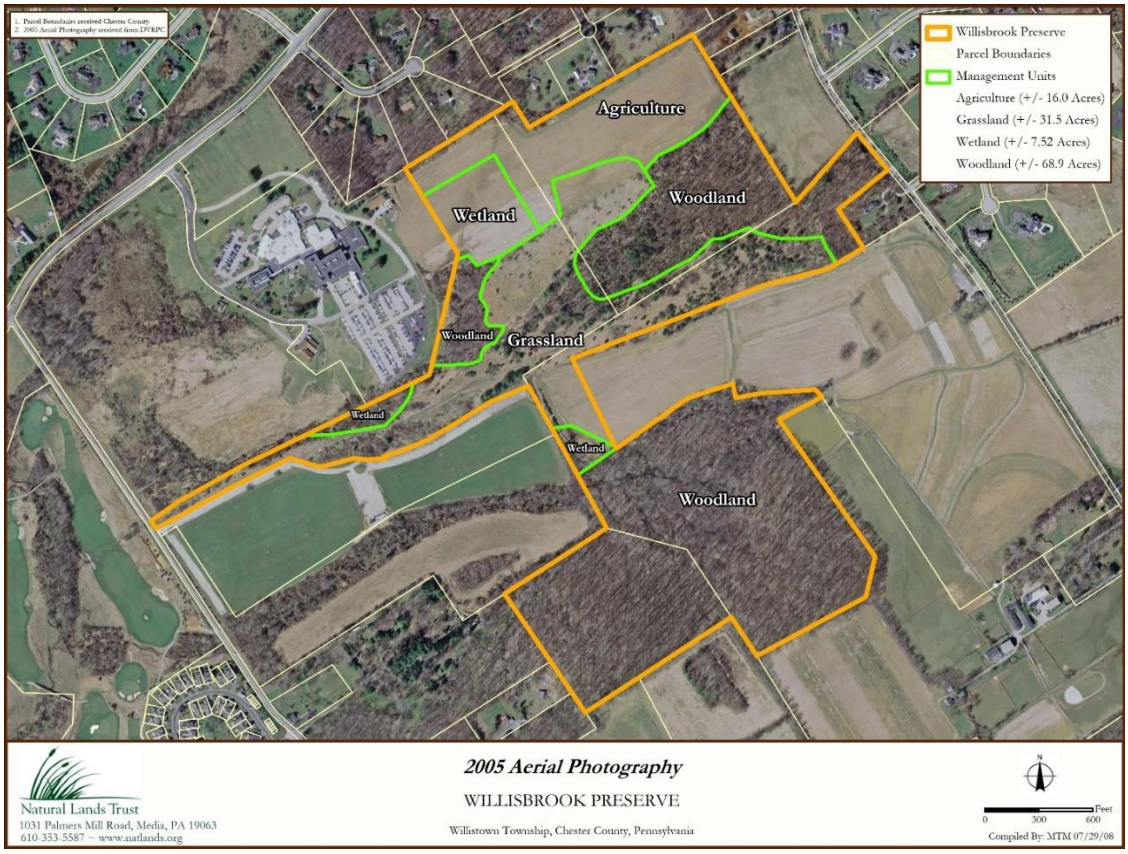
The Willisbrook Preserve, illustrated in Figures 16, 17, and 18 encases a serpentine barrens known historically as the Sugartown barrens. The Willisbrook Preserve has been managed by NLT since 1961, notably, this organization's first ever land donation (www.natlands.org). Figure 16 is a TNC map showing the borders of the preserve, and the acreage of the land types contained within the preserve.

When Pennell researched the vascular plant species here in 1910 and 1912, he found 93 species including nine serpentine endemics.

Pennell's list of nine serpentine endemics 1910, 1912:

Asclepias verticillata
Aster depauperatus
Cerastium arvense villosum (probably C. arvense villosissimum)
Cerastium oblongifolium (probably C. arvense villosum)
Fimbristylis laxa
Gerardia purpurea parvula
Panicum annulum
Phlox sublata
Talinum teretifolium

**Figure 16:** Willisbrook Preserve Land Use 2005 ~ The Nature Conservancy map




Roger Latham's (2010) email to Gary Gimbert of The Nature Conservancy lists 14 serpentine endemic species in the Willisbrook (Sugartown) serpentine barrens:

*Ageratina aromatica* (small-leaved white-snakeroot)
*Artistida purpurascens* (arrow-feather three-awn)
*Carex meadii* (Mead's sedge)
*Deschampsia cespitosa* (tufted hairgrass)
*Dichanthelium annulum* (annulus panic-grass)*
*Dichanthelium oligosanthes* (Heller's witch-grass)
*Fimbistylis annua* (annual fimbry)
*Linum intercursum* (sandplain wild flax)
*Packera anonyma* (Small's ragwort)
*Phemeranthus teretifolius* (fameflower)
*Quercus falcata* (southern red oak)

*Scleria pauciflora* (few-flowered nutrush)

*Symphyotrichum depauperatum* (serpentine aster)

*Symphyotrichum dumosum* (bushy aster)*

* not seen since 1982 (Latham 2010)

**Figure 17:** Willisbrook Preserve Pen Pilot Aerial Photo September 1937 in Google Earth

This recent list still includes serpentine aster, called *Symphyotrichum depauperatum* by Roger Latham rather than *Aster depauperatus* by Pennell, the fameflower called *Phemeranthus teretifolius* by Latham, and *Talinum teretifolium* by Pennell, and the bushy aster *Symphyotrichum dumosum* called *Aster dumosus* by Pennell. Pennell's *Panicum annulum* is probably Latham's *Dichanthelium annulum*. These lists are difficult to compare i.e. perhaps Pennell did not list *Quercus falcata* as he did not think it was a serpentine endemic, or was it simply not present at the time he inventoried the area? Pennell (1910) lists three oak species as being present in the Sugartown barrens: *Quercus palustris, Q. stellata,* and *Q. prinus.*

In Figure 18 I have approximated the grasslands area acreage in Willisbrook in 1937 by measuring the area of a polygon using the 2005 grasslands area map from TNC above and extrapolating from the 1937 aerial map. The current Willisbrook map (TNC) lists the following areas and acreage:

Agriculture (+/- 16.0 Acres)

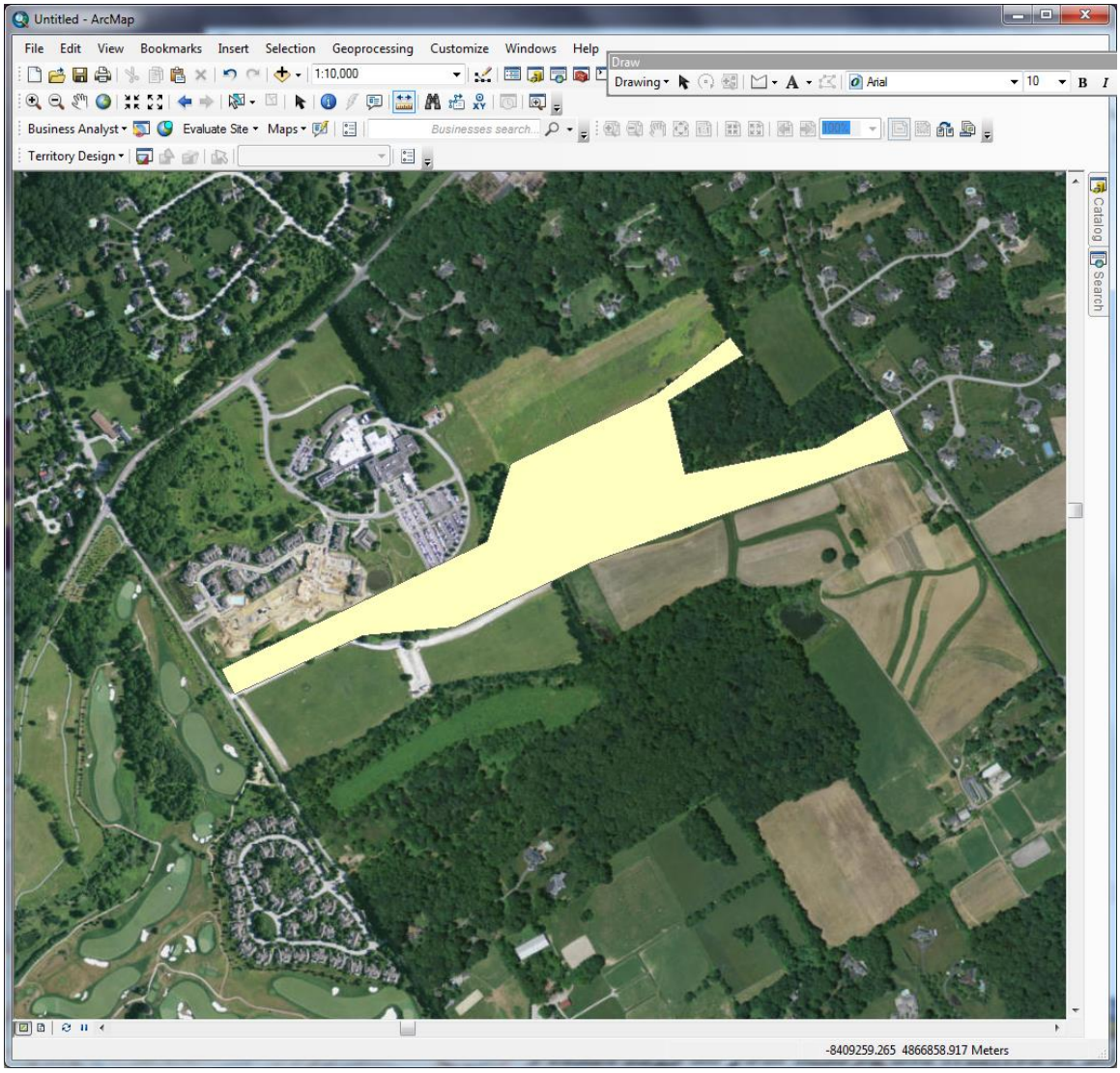
Grassland (+/- 31.5 Acres)

Wetland (+/- 7.52 Acres)

Woodland (+/- 68.9 Acres)

The polygon measurement of the 1937 grasslands area**,** about 77 acres, indicates that the grasslands have diminished by nearly 40 acres. The Nature Conservancy did not contribute any GIS data; I extrapolated the grassland area from the. jpg files that they sent.

**Figure 18:** Willisbrook Preserve grasslands 1937 ArcMap approximation




In Figure 19 there is a chart of four local Pennsylvania serpentine barrens including total acreage of preserved area (with the exception of Fern Hill/North Hill Neighborhood), the number of acres of open grassland in 1937, and the number of grassland acres in more current years between 2005-2011 ( Arcmap, Latham 2005, 2008 and TNC map data).

| **Figure 19**<br><br>**Barrens** | **Current Preserved Acres** | **Year** | **Grassland Acres** | **Year** | **Grassland Acres** |
|---|---|---|---|---|---|
| | | | | | |
| Fern Hill | | 1937 | 27 | 2011 | 9 |
| | | | | | |
| Pink Hill | 650 | 1937 | 14 | 2008 | 3 |
| | | | | | |
| Unionville | 1263 | 1937 | 58 | 2005 | 9 |
| | | | | | |
| Willisbrook | 124 | 1937 | 77 | 2005 | 31.5 |

In Figure 20 I have compiled an incomplete list of serpentine vascular plants beginning with Pennell's lists in 1910 and 1930, and more current data from Latham and TNC. Roger Latham and Janet Ebert's total vascular plant species of the Unionville barrens, including invasive and introduced species, numbers 173 (Latham 2005). These lists indicate that the number of endemics have decreased dramatically but the lists are problematic in that Pennell lists total vascular plants, then asterisks those he considers to be endemics. If we follow the endemic species that are given an asterisk (in parentheses) for Unionville and Willisbrook, the numbers change.

| **Figure 20:**<br><br>**Barrens** | **Year** | **Rare Serpentine Vascular Plants (Endemics)** | **Year** | **Endemics** | |
|---|---|---|---|---|---|
| | | | | | |
| Fern Hill | 1930 | 16 | 2015 | 4 | |
| | | | | | |
| Pink Hill | 1910 | 37 | 2008 | 4 | |
| | | | | | |
| Unionville | 1910 | 110 (11)* | 2005 | 15 | |
| | | | | | |
| Willisbrook | 1910 | 93 (9) | 2010 | 12-14 | |

Plant species data credits:

Fern Hill data: Pennell 1930, http://www.northhillpa.org/serpentine-barrens

Pink Hill data: Pennell 1910, Latham 2008

Unionville data: Pennell 1910-12 (total vascular species and endemics), *Latham (2005) Finds 19 rare species at the turn of the century; Latham and Ebert 2005

Willisbrook data: Pennell 1910-1912; Latham 2010 email to TNC

If Pennell's lists were reorganized alphabetically by barrens names, and old scientific names updated to new ones we might better interpret his data. Many of the plants, particularly grasses and sedges that he does not asterisk as endemics, might be endemic, or grassland relics that cannot survive in the shade and therefore become isolated and rare.

**Discussion**

Aerial photographs of the ten serpentine areas still extant in Pennsylvania clearly show the reduction of the open grasslands and savanna areas from 1937 to the present. These serpentine grasslands are home to rare and endangered flora and fauna. In a survey of the serpentine areas in Chester County done in 1994 for the Chester County Planning Commission, the list of endangered species of serpentine flora is coded to prevent poachers from locating these plants. I phoned the Chester County Planning Commission and spoke to Jake Michael (personal conversation 27 May 2015), a senior planner, regarding access to the plant codes so I could determine their locations. He indicated that the codes were unavailable unless permission was granted, possibly from the Western Pennsylvania Conservancy and even then I would need to provide academic or scientific credentials to proceed if in fact I could locate the department that would have these codes since the new political regime has brought about structural changes within the state organizations. Nonetheless, the list below is from Appendix VI of the 1994 survey of rare and endangered (special) plants in Chester County, created by the Pennsylvania Science Office of TNC.

SPECIAL PLANTS OF CHESTER COUNTY 1994

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| Adiantum pedatum spp. calderi | a maidenhair fern |
| Alopecurus aeaualis | short-awned foxtail |
| Alopecurus carolinianus | tufted foxtail |
| Androposon slomeratus | bushy bluestem |
| Aplectrum hyemale | puttyroot |
| Arabis patens | |
| Aristida purpurascens | |
| Asclepias varieaata | |
| Asplenium bradleyi | |
| Asplenium pinnatifidum | |
| Aster depauperatus | |
| Aster dumosus | |
| Aster solidagineus | |
| Bouteloua curtipendula | |

| | |
|---|---|
| spreading rockcress | Lvonia mariana |
| arrow-feathered three awn | Magnolia tripetala |
| white milkweed | Magnolia virginian |
| Bradley's spleenwort | Oxypolis rigidio |
| lobed spleenwort | Panicum annulum |
| serpentine aster | Panicum lucidum |
| bushy aster | Phaseolous polystachios |
| narrow-leaved white-topped aster | |
| tall gramma grass | |
| Carex bicknellii | Bicknells sedge |
| Carex buxbaumii | brown sedge |
| Carex aravida | heavy sedge |
| Carex tetanica | Wood's sedge |
| Cerastium arvense var. | - mouse-eared chickweed |
| villosissimum | |
| Chrvsopsis mariana | Maryland golden-aster |
| Cirsium horridulum | horrible thistle |
| Cvperus odoratus | rusty Elatsedge |
| Desmodium nuttallii | Nuttall's tick-trefoil |
| Diaitaria cosnatum | fall witch-grass |
| Elephantopus carolinianus | elephant's foot |
| Ellisia nuctelea | ellisia |
| Eupatorium rotundifolium | Boneset |
| Euphorbia purpurea | glade spurge |
| Festuca paradoxa | cluster fescue |
| Fimbristvlis annua | annual fimbry |
| Helianthemum bicknellii | Bicknell's hoary rockrose |
| Ilex maca | American holly |
| Juncus biflorus | grass-leaved rush |
| Juncus dichotomus | forked rush |
| Leucothoe racemosa | swamp dog-hobble |
| Linum intercursum | sandplain wild flax |
| Lobelia puberula | downy lobelia |
| Lupinus perennis | wild lupine |

| | |
|---|---|
| stagger-bush | Viburnum nudum |
| umbrella magnolia | Woodwardia areolata |
| sweet bay magnolia | Zannichellia palustris |
| stiff cowbane | Zizania aquatic |
| annulus panic-grass | |
| shining panic-grass | riverweed |
| wild kidney bean | cross-leaved milkwort |
| | Curtis's milkwort |
| | pink milkwort |
| Podostemum ceratophyllum | southern red oak |
| Polygala curtissii | lettuce saxifrage |
| Polygala cruciate | few flowered nutrush |
| Polygala incarnate | reticulated nutrush |
| Quercus falcate | plain ragwort |
| Saxifrasa micranthidifolia | spring ladies-tresses |
| Scleria pauciflora | prairie dropseed |
| Scleria reticularis | pencil flower |
| Senecio anonymus | round-leaved fame-flower |
| Spiranthes vernalis | cranefly orchid |
| Sporobolus heterolepis | tawny ironweed |
| Stulosanthes biflora | possum haw viburnum |
| Talinum teretifolium | netted chainfern |
| Tipularia discolor | horned pondweed |
| Veronia glauca | Indian wild rice |

This list contains 67 species that were found in serpentine areas in Pennsylvania in 1994. No indication is given of location or importance within the habitat. Another inventory, twenty years later, would inform us of how many of these special plants species can still be found.

Jake Michael (2015) remarked that sometimes creating awareness of "keystone species" can be used to expand conservation efforts. He cited the example of freshwater mussel awareness in Pennsylvania and how focusing on the habitat of this one species segues into the improvement of the habitat of all related species in that ecosystem. One or

two serpentine species, perhaps the warm season grasses, might become a keystone plant for saving the grasslands, thereby helping all of the interrelated flora and fauna of the serpentine grasslands.

It is clear from aerial photographs that the grasslands are shrinking and that many more small serpentine areas were in existence in Pennsylvania at the turn of the century than exist today. With the decrease or absence of disturbance regimes such as fires, grazing and logging, management of serpentine areas becomes a massive effort involving time, money, and volunteers. The priority of the management efforts must be to keep the remaining grasslands open and to reclaim and restore former grassland areas in order to reduce the possibility of species extinction.

On a recent visit to the Unionville barrens the deep tractor tire marks and great mounds of cut trees indicated one management process by the Natural Lands Trust of logging *Juniperus virginiana* and hauling the cut trees away. In the Nottingham serpentine barrens a ranger on duty directed a group of us to "managed areas" where great efforts were being made to cut down trees including *Juniperus virginiana* and *Pinus virginiana* that were then chipped, and all debris hauled away to prevent soil build up.

During the February 2015 Nottingham Park meeting of serpentine "friends", scientists, and volunteer leaders, one of the friends of the barrens noted that one aspect of their plan included linking the separate barrens by trails, increasing the members in the friends' group, increasing the number of volunteers available for the work needed to keep trails and grasslands open, and seeking grant money or donations to assist in carrying out management plans. Henry Whitesel and Mike Bertram, longtime volunteer group leaders in the Goat Hill barrens, added that their plans included cutting and dragging invasive trees from the area, mowing, burning, scraping of deep soils, and using herbicides on specific invasive stumps. I imagine that finding volunteers to cut green briar and dig up red cedars and young pines is a challenge.

**Conclusion**

It bears reiteration that temperate grasslands and savannas are the most endangered of any ecosystem in the world (Latham 2005). Eastern North American

serpentine grasslands and savannas are endangered by the encroachment of developments and invasive plants and the reduction of disturbances such as fires and grazing animals. Many of the smaller serpentine grasslands that were researched by Pennell (1910, 1912, 1930) and Harshberger (1903, 1904) at the turn of the last century have disappeared through human activity or neglect. The unique endemic flora and fauna of the barrens will disappear unless management practices to reverse this trend such as logging, burning, scraping, replanting, and removal of invasives are ongoing.

That the grasslands acreage is shrinking is clear and has been further documented by this research. Evidence suggests that small populations are at greater risk of going extinct than large ones (Kruckeberg and Rabinowitz 1985). Small isolated preserves are certain to lose species (Noss and Cooperrider 1994). The biodiversity of these grasslands appears to be diminishing. The Willisbrook barrens areas which have been managed by TNC since 1961 has a significant intact grassland area. Historic plant listings and current plant listings need further organization in order to be clearly analyzed. Serpentine grasslands warrant legal protection, further scientific research, and intensive management so that we might save these remnants of our geologic and archaeologic past before they are gone.

A friend and I walked through a section of the Unionville barrens on private property outside of the Cheslen Preserve in April 2015. We made our way through the woods on winding deer paths, as walking through the ubiquitous green briar was not an option. We came upon an area of open grassland, possibly 50 feet by 50 feet, shown in Figure 21. This area at first glance appeared quite devoid of living things. But on closer inspection we found several species of endemics in bloom including *Phlox sublata*, Figure 22. In the middle of a mixed deciduous forest, this open space seemed an odd but rare oasis that provided an opening to consider who and what had been here before us, and an opening for this research to continue.

**Figure 21:** Small open grassland on private property outside of the protected Cheslen preserve in Unionville, Pennsylvania.

Photos above and below by k.rengert photography

**Figure 22:** Phlox sublata blooming in the small grassland.

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